National Aeronautics and Space Administration

PLANETARY PROTECTION ADVISORY COMMITTEE

October 1–2, 2002
Columbia I Room, Holiday Inn Washington Capitol
550 C Street SW, Washington, DC

MEETING REPORT

John D. Rummel	Norine E. Noonan
Executive Secretary	Chair

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
Columbia I Room, Holiday Inn Washington Capitol
550 C Street SW, Washington, DC
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Tuesday, October 1, 2002

Welcome and Meeting Overview
Dr. Norine Noonan, Chair of PPAC, called the meeting to order and welcomed the committee members, liaisons from other federal agencies, representatives from international space agencies, and other meeting attendees. In reviewing the meeting agenda, Dr. Noonan noted that Dr. Edward Weiler, Associate Administrator (AA) for Space Science, would come by late Tuesday morning to hear any recommendations and discussion items from the committee.

Report from the NASA Advisory Council
Dr. Noonan summarized the September 10–11, 2002, meeting of the NASA Advisory Council (NAC), which was held at Jet Propulsion Laboratory (JPL). The first half-day focused on the International Space Station (ISS). The NAC discussed the research agenda of the Office of Biological and Physical Research (Code U) and the report of the Research Maximization and Prioritization (REMAP) Task Force on prioritizing ISS research. Ms. Mary Kicza, as the new Code U Director, reviewed the NASA response to the REMAP report, including operational changes. Dr. Noonan noted that NASA still has much to do to respond to the recommendations. After the REMAP session, the NAC visited the assembly area for the Mars Exploration Rovers. The first Rover is scheduled for launch in May, the second in June, and Dr. Noonan remarked that the schedule to prepare the Rovers is ambitious. They are being built and assembled under clean conditions. The NAC was briefed on the ongoing reorganization of NASA's education programs, which are being brought together as a new Enterprise, the NASA Education Office. The education staff who were administratively under separate programs before will report within the new office, although they will still be physically located in their program offices as liaisons. The reorganization is intended to increase program effectiveness. A principal aim is to raise NASA's profile in kindergarten through 12th grade education and make NASA's educational materials more useful to teachers. Dr. Adena Loston has been named as a Special Assistant to the Administrator for education. NASA is also seeking funding authority from Congress for a program of Scholarships in Service, which would offer scholarships for postgraduate study in return for service with NASA after the degree is awarded. The purpose is to interest new scientists in a NASA career. The NAC was briefed on an education program by JPL, California Institute of Technology, and Arizona State University to involve students in planning some of the Mars Odyssey observations.

Dr. Laurie Zoloth added that the REMAP report is a work in progress. A report from a National Academy of Sciences study committee also came out this summer. The reports provide a clear assessment of how far NASA still has to go. Dr. Zoloth remarked on the tension between the requirements for preparing space exploration missions and the basic science to be done along with the exploration mission, balanced against externalities of budget constraints and other national priorities. Observing the assembly work on the Rovers brought home to Dr. Zoloth the importance of PPAC's work in sending out equipment, like the Rovers, that will land on another planet.

Annual Ethics Training
Ms. Laurie Rafferty, the NASA Senior Ethics Attorney in the Office of the General Counsel, provided the 2002 annual ethics training for those committee members who are special government employees (SGEs). She reviewed the applicable provisions under the Criminal Conflict of Interest Statutes (18 USC 201–216) and the Standards of Conduct Regulations (5 CFR 2635 and other regulations). In response to a question about whether activities on multiple committees count toward the 130-day limit in any 12 months for special government employee (SGE) status, Ms. Rafferty said she would investigate the issue and inform the committee. **[Action # 1. Laurie Rafferty will provide information on whether service on multiple committees, etc., counts toward the 130-day limit for a special government employee.]**. In reviewing the criminal penalties, Ms. Rafferty noted that they usually do not apply to SGEs. For SGEs, the stricture against representing a third party to the government only applies to matters pending before the home agency (in this case, NASA) when: (1) the individual has worked on that matter substantially and

personally as a government employee or SGE, and (2) the SGE has worked for the home agency for more than 60 days in the preceding 365 days. Section 203 states that a SGE cannot accept compensation for representation, but Section 205 states more broadly that the SGE cannot represent a third party at all (if the above conditions are met). Section 208 is the section that requires a review of an SGE's personal financial situation for a financial conflict of interest. Examples discussed include owning stock of a corporation that does business with NASA. Financial conflict can be resolved by an individual waiver, recusal or disqualification, or the SGE's divestiture of the holding. Negotiating for employment with a company counts as a financial interest in that company. Section 207 prohibits SGEs from representing a third party back to NASA on a matter they have worked on "personally and substantially" as an SGE. Ms. Rafferty said it was unlikely that anything a PPAC member worked on as committee member would meet the "personal and substantial" condition for section 207. The Standards of Ethical Conflict prohibit soliciting or accepting gifts from "prohibited sources," if the gift is given because of the SGE's official position. There are some frequently used exceptions for gifts of limited value. Prohibited sources include individuals and organizations: (1) doing business or seeking to do business with NASA, (2) affected by the performance of the SGE's official duties, or (3) seeking action from NASA. One of the exceptions is for a "widely attended gathering," and a list of these is maintained on the General Counsel's website. Ms. Rafferty noted that the requirement of impartiality includes avoiding even an appearance of partiality. An appearance of partiality may arise if anyone with a "covered relationship" to the SGE (committee member) has a financial interest in the outcome of an action that might be influenced by the work of the SGE for NASA. As a closing caveat about the ethics rules, Ms. Rafferty noted that the rules are complex, with many prohibitions, exclusions, and exceptions that depend on context and the details of a particular situation. Members with a question on the ethics rules should contact Ms Rafferty, Mr. Paul Pastorek (NASA General Counsel), or Mr. Robert Stephens (Deputy General Counsel).

Planetary Protection Program Status /Plans

Dr. John Rummel reviewed the status of and plans for NASA's Planetary Protection (PP) program. NASA's Planetary Protection Policy includes requirements based on a 1992 report by the Space Studies Board (SSB) of the National Research Council (NRC), *Biological Contamination of Mars: Issues and Recommendations*. The NASA policy documents, which are undergoing review and revision by Dr. Rummel's office, include the basic directive (NPD 8020.7); NPG 8020.12, which focuses on extraterrestrial robotic missions; and NPG 5340.1, which specifies microbial assay procedures to assess spacecraft contamination. The four activities within the PP Program are project monitoring, implementation/ requirements analysis, program and study support, and research on standards and requirements. The AA for Space Science, who has overall responsibility for NASA PP policy, has delegated authority to the Planetary Protection Officer (PPO) for PP measures involved in launches and returns of materials. Specific measures that are taken include (1) reduction of spacecraft biological contamination, (2) constraints on spacecraft operating procedures, (3) spacecraft organic inventory and restrictions, (4) restrictions on the handling of returned samples, and (5) documentation of spacecraft trajectories and spacecraft material archiving. The PPO is supported by activities at three field centers: Ames Research Center (ARC), JPL, and Langley Research Center (LaRC). The Genesis mission, which is experiencing a battery problem, is intended to be the first post-Apollo sample return from beyond low-Earth orbit. A descent onto Titan is part of the Huygens Probe mission scheduled for 2004. This is a European Space Agency (ESA) project, in conjunction with NASA's Cassini mission to Saturn. With respect to issues about exploration of Europa, one model that has been suggested is the plan for exploration of the lakes below the Antarctic ice cover (see presentation by Joyce Jatko). PP issues associated with the Mars Exploration Rovers are discussed in the presentation by Dr. Orlando Figueroa. The Stardust mission, which is planned to return samples in 2006, is discussed in Dr. Colleen Hartman's presentation. International agreements are an essential part of the PP Program, and PP is a U.S. treaty obligation from the 1967 UN Space Treaty. Forward contamination during missions to Europa and Mars are near-term issues. The Europa mission may become a mission under the New Frontiers competed program. Back contamination may be a larger issue for the spring PPAC meeting, related to future missions with sample return. Some Mars missions may require reduction of the bioburden carried by the spacecraft. Dr. Rummel reviewed the NRC/SSB studies and key recommendations on PP, beginning with the 1992 report and continuing through reports on *Preventing the Forward Contamination of Europa* and *The Quarantine and Certification of Martian Samples*, in 2000 and 2001, respectively. A 1998 report provided recommendations on sample returns from small bodies (planetary satellites and small solar system bodies). The SSB report on human missions to Mars

recommended "zones of minimal biological risk." In summary, Dr. Rummel said the Planetary Protection Program appears to be in good shape from NASA's internal perspective and in terms of interactions with others outside the agency. Ongoing programs are in place with mission developers to implement PP policies.

Dr. Noonan asked if the Mars Exploration Program is addressing the need for facilities to receive returned samples. Dr. Rummel suggested that would be a good question for further discussion on Day 2, along with discussion of the capabilities that will be needed in facilities to handle samples returned from Mars missions or other solar system exploration missions. He discussed issues in planning for such facilities. Mars samples might be the first ones back that would raise the issue of having life on them. Sample returns for the Solar System Exploration Division (SSE) are further in the future than sample returns from Mars. The National Institute of Allergy and Infectious Diseases (NIAID) is interested in building several biosafety level (BSL) 4 laboratories around the country. Dr. David Klein (from NIAID) noted some of the: issues in initiating and establishing such facilities. Communities where laboratories might be located are concerned about how well they would quarantine potential hazards. Dr. Colleen Cavanaugh raised the issue of the kind of regulatory environment that will, in time, constrain human exploration missions. She is concerned about regulations to control contamination might get out of hand. Can regulations be built down (relaxed or removed), as well as built up? Dr. Rummel said this issue fits well with the results from a workshop last year on human exploration, which he will distribute for a future PPAC meeting. Among the issues the workshop addressed was the isolation of returning Mars astronauts. There are other return issues with human missions to the Moon and other near-Earth objects. For Mars, the SSB report recommended a series of unpiloted missions first, to understand the potential for contaminating the planet. For NASA the concern about Mars contamination has been to not ruin the potential to do science on potential (past or present) native martian life. Dr. Ronald Atlas said that a transition will be needed at some point from the scientific need to prevent contamination [of Mars with Earth-derived organisms or products] to the scientific experiment of trying to grow "crop" plants on Mars. Dr. Rummel replied that at present the compelling science questions address what is native to Mars and the issue of past interactions between Earth and Mars that may have left signs of life. Dr. Rummel also referred to Dr. Garvin's presentation (see "Mars Contamination Aspects and Planning" below), which discusses the potential for subsurface water on Mars, based on results from recent measurements. This evidence raises the issue of which martian locations (for example the subsurface, as well as specific surface terrain features) should be protected from potential contamination. Research projects on PP have been looking at these issues, as well as issues about contamination from past spacecraft crashes on Mars and methods for getting bioburden measurements on spacecraft and components in near-real time rather than waiting several days for culture methods.

Dr. Robinson noted that there are many laws, including common law procedures, that groups opposed to a science mission can use to delay it. So there is also an issue of getting "informed public consent" to mission approaches, to preclude last-minute legal obstacles. Not much work has been done on how to create an infrastructure for getting informed "international public consent." Dr. Rummel said that a discussion on education and outreach, which would touch on these issues of informing the public, is one of the topics he is considering for the next PPAC meeting. The Mars program has an elaborate public communications strategy. Part of the reason for the structure of PPAC is to provide a forum where the foreign representatives from ESA, Japan's Institute of Space and Astronautical Science (ISAS), the Canadian Space Agency, and others can present their PP approaches and issues. One role of the Planetary Protection Program in NASA is to communicate to the broader public the reasons why the actions being taken are sound and responsible. In response to Dr. Eugene Levy's question on whether any other human action has achieved global informed consent, Dr. Zoloth drew analogies with the Human Genome Project and issues with acquiring community consent to map the genome of distinct ethnic/geographic origin groups. She pointed out that the process should consider dissent from, as well as consent for, actions like these, in which individuals or groups have no way to opt out of being involved. Thinking about this as a global issue is a leap in human consciousness. Dr. Orr remarked that the timing for next year is important because of the close approach between Mars and Earth; it would be a good time to piggyback these issues on the increased public awareness of Mars in relation to Earth. Dr. Rummel added that NASA needs to communicate clearly to the public why cautions are being taken, to allay distrust in what NASA is doing. In addition, people's attitudes toward other science-related issues, such as genetically modified foods, may influence their attitude toward PP issues.

COSPAR Planetary Protection Panel Status/Plans

Dr. Rummel reviewed the charter of the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU). COSPAR has a formal role in international agreements and treaty obligations through its recognition by the Committee on Peaceful Uses of Outer Space (COPUOS) of the United Nations. The COSPAR Planetary Protection Panel, which was formed in 1999, focuses on international policy. The Panel held a workshop in Williamsburg, Virginia, on April 2-4, 2002, to draft documents and resolutions to be considered by the COSPAR Bureau and Council at or before the World Space Congress this fall. The report of the COSPAR workshop was distributed to the PPAC members. COSPAR's provisions related to planetary protection, some of which date back to 1964, were organized and integrated within one document for the Warsaw Scientific Assembly in 2000. Specific policy issues addressed at the April 2002 workshop included the PP status of the Beagle-2 mission to Mars (an ESA mission) and the MUSES-C asteroid mission, which includes sample return, by ISAS. As stated in the proposed PP Preamble, the purpose of the COSPAR PP policy is to provide an international standard on procedures to avoid organic-constituent and biological contamination in space exploration and to provide guidelines for compliance with the United Nations (UN) space treaty and other international agreements. These procedures provide for voluntary notification to COSPAR of procedures for controlling spacecraft bioburden and computations of bioburden for each space flight, to be reported within 6 months after launch. COSPAR will maintain a repository for these reports; it does not have an enforcement role (and enforcement is not included in the UN Space Treaty). The U.S. member of COSPAR is the National Academy of Sciences. The reporting requirement does provide for some degree of "moral suasion," as well as potentially providing information to other nations/agencies on the procedures used by missions undertaking space exploration. The mission categories from I to V are based on planet priorities and the mission type. Categories I through IV deal with forward contamination concerns; mission category V applies to all Earth-return missions (issues of back contamination). Human missions are not directly addressed by the COSPAR categories. The workshop developed consensus implementation guidelines for abandoning sample return in a Category V mission. It also developed requirements for Category III, IV, or V missions to Mars. Category IV (lander and probe missions) were divided into three subcategories, depending on whether they carry instruments for investigation of extant martian life or would contact "martian special regions" of interest to questions about life on Mars. (Details of the provisions are in the draft PP Policy, included in the COSPAR workshop report.)

In response to questions from PPAC members, Dr. Rummel explained why the Viking sterilization procedure is still used as the de facto standard. The Viking standard of heat sterilization is applied to Category IV missions to special regions because it is well characterized as a procedure for minimizing bioburden and represents the state of practice in sterilizing spacecraft. Hydrogen peroxide sterilization is being tested and considered but is not yet a qualified method. PPAC members asked questions about thermophiles (organisms that can survive in hot environments) and the sensitivity of new materials, particularly electronic materials, to sterilization heat levels. The current COSPAR (and NASA) Category IV standard includes both total spacecraft bioburden (3×10^5 spores per landed element) and surface area bioburden (300 culturable spores per square meter). These standards are based on what can be counted (culturable spores), and therefore are only an indicator of total bioburden. With respect to alternative methods of detecting bioburden, Dr. Rummel noted that one problem is establishing comparability with the culturable spores standard. Other methods, such as molecular methods, are available, but they not readily compared to the existing de facto standard. Dr. Rummel thinks the PP community is awakening to the need to reconsider the standard. Expenditures now on research in spacecraft decontamination are an order of magnitude below what was spent during Viking development. A method is needed that is repeatable and can be carried out reliably in an industrial setting. The current methodology is useful because the principal concern has been aerobic spores. Research is being done on screening materials for compatibility with different sterilization methods, including hydrogen peroxide and heat sterilization. **[Action #2. For the next meeting, staff will report on research that has been done on sterilization and detection methods. The committee will consider recommendations on moving ahead with alternative methods.]**.

The draft COSPAR PP policy includes quarantine and decontamination standards for sample return from missions to Mars, Europa, and small solar bodies. These standards are based on the SSB report recommendations. There will be a symposium at the World Space Congress in Houston on October 16,

with papers on preservation of solar system conditions and preservation of Earth's biosphere, including legal and ethical issues, international policy, and public communications. In response to a question from Dr. Zoloth, Dr. Rummel iterated that COSPAR only has the sanction of "moral suasion." COSPAR is a forum for discussions, created in the 1950s. It maintains international consensus standards for planetary protection that are voluntary and serves as a repository for voluntarily submitted reports. Space-faring nations can adopt the standards or not. COSPAR has a "consultative body" relationship with the UN Committee on Peaceful Uses of Outer Space, but even the UN Space Treaty only has the force of moral suasion outside the United States.

Mars Express Planetary Protection Status/Plans

Dr. Gerhard Schwehm, the international representative from the ESA, gave an overview of the science and mission aspects of the Mars Express mission, including PP aspects of the mission. This is a medium-size mission with an orbiter and a lander. It uses subsystems similar to those in the Rosetta mission. The instruments are based on those for the unsuccessful Mars 1996 mission. The lander is being developed for ESA through a public-private partnership with several institutes. ESA did not have sufficient budget to fund a lander on its own. The Mars Express orbiter will provide high-resolution photogeology at 10 m/pixel, mineralogical observations at 100 m/pixel. The Mars Express lander, Beagle-2, will search for life signatures, study geology and mineralogy of the landing site, and assess organic and mineral geochemistry, meteorology, and climatology. Exobiology instrumentation on the lander will look for carbon isotopic ratios, rock dating, iron phases formed in water, and microfossil structures. Instruments for surface/subsurface studies include spectrometers like those used in Rosetta and Galileo, the MARSIS subsurface radar, and instruments for mineralogical analysis (OMEGA). The science objectives for Beagle-2 include detection of extinct or extant life, analysis of subsurface materials and regimes, trace element analysis of rocks and soils, and in situ radiometric dating of rocks. Astronomical observations of Mars moons will be used to locate the lander precisely on the martian surface. A key aspect of the Beagle-2 probe, according to Dr. Schwehm, is its advanced, complex engineering. It is a small, highly integrated probe with no subsystem redundancy. The launch mass is 68 kg; the landed mass is 32 kg, with 9 kg of payload. The expected operational duration is 180 sols. Launch is scheduled for the end of May 2003, with Mars rendezvous in December 2003. A parachute and air bag system, like that used for Pathfinder, will be used to land the probe. The Beagle-2 Landing Site is Isidis Planitia, a site with evidence of resurfacing and rock slides, perhaps with mobile dust. In response to a question, Dr. Schwehm said he believed it has recently been reconsidered as potentially having subsurface moisture, but will provide further information to PPAC. **[Action #3. Dr. Schwehm will provide information on what is known about subsurface moisture at the Beagle-2 landing site.]** A deployable subsystem, PAW, is an integrated collection of scientific instruments and sample preparation and acquisition tools for in situ investigations of the martian surface. The Mole unit can dig either vertically (into the surface) or horizontally (e.g., beneath a surface rock) to acquire soil samples for analysis. The gas analysis package can analyze for organic matter, carbonates, organic nitrogen, atmospheric composition, methane, rock dating, soil exposure ages, and extent of hydration. With respect to mission status, the orbit mapping will be set in November 2002. The orbiter will be shipped to Baikonur, Kazakhstan, in February 2003. Flight module assembly has begun on the Beagle-2 lander, and it should be delivered in December 2002.

With respect to PP, although the lander is provided to the ESA by a separate consortium, ESA is taking responsibility for PP implementation and the reporting to COSPAR for Beagle-2. A subcommittee of the Royal Society Space Committee has been established to determine PP requirements for Beagle-2. Microbial contamination control must satisfy both the COSPAR requirements and the science requirements for validity of exobiological measurements. With respect to the latter, five criteria for life processes that could have operated on Mars are potentially affected by contamination carried by the spacecraft. The Beagle-2 PP implementation plan has been delivered to ESA, but it cannot be released until the developers report to COSPAR at the World Space Congress. (The Beagle-2 developers claim intellectual property rights are at stake.) The PP plan includes microbial and chemical contamination analyses, a microbiological assay plan, and a microbial reduction/control plan. Dr. Schwehm agreed with the developers' claim that the plan exceeds the requirements for COSPAR Category IVa and complies with NASA document NPG 8020.12B. Fairly sophisticated sterilization and clean-room procedures are needed during assembly and integration of the Beagle-2 probe to prevent any carbon contamination of any parts that would contact the gas analysis instruments. Dry heat sterilization will be used for some elements;

irradiation will be used for plastics, such as the parachutes. The developers have had pharmaceutical companies review their clean room procedures. In response to questions, Dr. Schwehm and Dr. Michel Viso described procedures for keeping the Beagle-2 payload clean during Mars Express assembly and launch preparations at Baikonur. A clean room tent will be set up at the assembly site. The launch vehicle is a Soyuz rocket with upper stage. Although Russia is the launching country, ESA is taking responsibility for PP reporting to COSPAR. Dr. John Kerridge asked that PPAC consider discussing intellectual property claims and how they may affect the role of the PPAC. Dr. Rummel noted that intellectual property issues have affected other aspects of cooperative missions, and it may affect aspects of PP in the future.

Update, Solar System Exploration Program

Dr. Colleen Hartman, SSE Division Director, updated PPAC on the SSE program, including the Near Earth Asteroid Rendezvous (NEAR) mission, Galileo, Cassini, Deep Space 1 (DS-1), Stardust, and Genesis. Cassini is on track for insertion into orbit around Saturn in 2004. DS-1 has sent back observations from Comet Borrelly, including good pictures. Stardust will return with samples of comet dust and pre-solar nebula samples. The return site for these samples is in the Utah desert. Genesis sample recovery (solar wind materials collected at the Earth-Sun libration point) is set for September 2004, although the impact of the temperature problem with its battery is not yet certain. For now, the worst-case option would require closing the collectors for all three solar wind regimes earlier than planned. The Comet Nucleus Tour (CONTOUR) spacecraft was lost during solid rocket motor burn on August 15. Everything was operating perfectly prior to that burn. The spacecraft was probably destroyed during the last 3 seconds of the burn. A Mishap Investigation Board is in progress, chaired by Theron Bradley, NASA Chief Engineer. There will be a Deep Space Network campaign in December to attempt contact. A replacement CONTOUR mission may be proposed to a future Discovery program competition. The Deep Impact spacecraft, under the Discovery program, is under construction for launch in 2004. However, cost is a concern, and Deep Impact may be in danger of exceeding its price cap. The Messenger mission to Mercury, which Dr. Hartman described as an ambitious mission, is on track.

The New Frontiers program, which will select missions through a competitive process, is included in the President's Budget for fiscal year 2003 (FY 03). This program in part replaces the cancelled Outer Planets program but is not limited to the outer planets. The Decadal Report from the SSB prioritized five missions for New Frontiers. However, no starts can be made until the FY 03 authorization bill is signed. Constraints on the New Frontiers program include no foreign launch vehicles or foreign radioisotope thermoelectric generators (RTGs). The program as proposed ramps up from $15 million in FY 03 to $240 million in FY 05. Under the existing Discovery program for competed missions, the new selections are Dawn and Kepler. The objective of the Kepler mission is to search for Earth-size planets.

The Nuclear Systems Initiative (NSI) is also in the President's Budget for FY 03. One part of NSI will develop RTG alternatives to expand the power available for surface exploration missions and increase the operational life of missions, thereby increasing the science return. The 2009 Mobile Surface Laboratory mission to Mars will use RTGs as a radioisotope power source (RPS). Dr. Hartman compared the advantages of nuclear electric propulsion, another research area under the NSI, for exploring the Galilean satellite (Europa, Ganymede, and Callisto). Nuclear-propelled missions would not be power limited and multiple landers may be possible. Whereas chemical propulsion would allow for only 30 operational days, nuclear electric propulsion could increase mission life to 2–3 years. However, there are issues for NSI or any launching with radioisotopes. The NSI as proposed is just a research and development (R&D) effort. An NSI Science Concept Definition team has been created. The Office of Space Science is the "user community" for the NSI and must guide it over the next two decades. All current RPSs use plutonium-238 (^{238}Pu), in the form of compressed-powder pellets, as the radioisotope. Domestic production of ^{238}Pu is expected to resume in FY 09, but fuel for missions will not be available until 2012. Until then, the principal supply is Russian. NASA is planning to get more ^{238}Pu from the Russians. Plutonium for use by NASA is always owned by DOE, and any RTG remains DOE equipment. Most of the program that began in FY 02 to investigate nuclear propulsion techniques will move under the NSI. For the first time, significant funding is going into this area.

SSE used an external committee (10 members with no direct NASA role) to perform a bottom-up technology assessment. However, PP technologies was one of three areas that were not assessed. Dr.

Hartman sees this assessment as the first in an iterative process, with PP technologies being covered in a later phase. The committee attempted to apply a cost-to-benefit assessment metric, but the approach turned out to be more difficult than expected. The committee concluded that the difficulty in assessing cost versus benefit made it impossible to set priorities across technologies on the basis of objective criteria. Another observation was that scientists implicitly limit scientific objectives to what they believe is affordable, technically achievable, or within acceptable technical risk. Dr. Hartman saw this point as significant for the NSI, which is attempting to introduce a new paradigm.

Dr. Hartman next discussed the significance of the SSB Decadal Survey for SSE. The process used in these surveys increases input from the broader science community. NASA astrophysics has used this approach for years. In this first decadal survey done for solar system missions, the SSB divided priorities into three mission cost classes. The small class (missions less than $325 million) includes the Discovery missions and the Cassini Extended mission (CASx). The medium class (less than $650 million) would come under the New Frontiers program, with a Kuiper Belt/Pluto mission as the top priority. The second priority would be a Moon mission with sample return. Dr. Hartman views these as ambitious missions that might not come in under the $650 million cap for New Frontiers. For example, JPL estimated the cost for the third priority in this class, a Venus in-situ explorer, at more than $1 billion. The procurement approach may be to have an Announcement of Opportunity (AO) for multiple missions, since some specific-mission proposals may not be able to come in under the cap. Two places outside NASA to which SSE can look for realistic cost analyses are Aerospace Corporation and SAIC. Two of the priority medium-class missions would include sample return, and handling of the returned samples is part of the mission scope for both. This point led to a discussion with PPAC members on how best to provide for sample handling facilities for multiple sample-return missions. For the large-class, or "flagship mission" recommended by the SSB, there is no money in NASA's budget. Having a priority in this class does allow NASA to look at possibilities. Each flagship mission will need specific congressional authorization. Dr. Levy noted the importance of a Europa mission, which would be in this size class, because of the significance of Europa for questions about extraterrestrial life. Dr. Noonan remarked that the solar system exploration community is active, and the SSB decadal survey has put the imprimatur of the National Academy of Sciences on SSE programs. PPAC discussed the relation of the survey and the technology assessment to REMAP. The Office of Space Science and the Earth Science Enterprise were not included in the REMAP exercise.

Planning for Antarctic Lake Studies

Dr. Joyce Jatko, of the Office of Polar Programs, National Science Foundation (NSF) described the context and status of plans for scientific studies of the newly discovered subglacial lakes in Antarctica. The presentation highlighted similarities with PP issues. In particular, these lakes can serve as analogues for ice-covered bodies in the solar system, such as Europa. Activities in Antarctica might be useful as a test bed of technologies for planetary exploration/protection. To date, 70 subglacial lakes have been identified, with Lake Vostok being the largest. For hundreds of thousands of years, these lakes have been isolated from interaction with the surface and from direct exposure to Earth's atmosphere by the thick ice sheet above them. They are 3 to 4 thousand meters below the ice sheet surface and appear to rest on the continent; that is, there is no ice below them. The presence of a large lake was first reported in 1996 (Lake Vostok). The Scientific Committee for Antarctic Research (SCAR) established an international Subglacial Antarctic Lake Exploration Group of Specialists to deal with the science, technology, and environmental protection issues. Workshops were held, and the focus broadened from Lake Vostok to subglacial lakes in general. With respect to planning for the science, non-contaminating techniques are needed for lake entry (drilling) and sample retrieval (water and sediments). The scientific objectives include detection and characterization of life (if any) in the lakes. In response to a question from Dr. Robinson, Dr. Jatko explained the significant differences between the subglacial lakes and the Antarctic dry valley lakes. In the latter, much work was done long before there were concerns about contamination. Dr. Diana Wall added that the perimeters of the dry valley lakes melt annually, so there is a physical interface between the liquid water in the lakes and the atmosphere. The technology challenges in the science plan for the subglacial lakes include access methodologies, non-contaminating systems, sampling devices, and sample return procedures. Dr. Jatko presented a timeframe matrix that related the major scientific objectives to phases in lake entry and sample retrieval. Collaborative efforts are underway to establish a technology roadmap for exploration and sampling of Lake Vostok. In response to a question from Dr. Robinson, Dr. Jatko said there are no clear answers as to how the international patent convention would apply to these technologies

or to life forms discovered in the lakes. Under the Antarctic Treaty, data sharing is a requirement, but questions about the technology used to acquire data have not arisen yet. The issue of finding microorganisms and patenting them is a looming question. Ice cores from the "accretion zone" (where lake water freezes against the bottom of the ice sheet) contain what appear to be bacterial and viral bodies. However, there are questions as to whether these represent contamination from the drilling fluid. Two studies are underway on decontaminating the cores. Over the years in which drilling through the ice sheet was in progress, drilling fluids changed from diesel oil to Freons to other chlorofluorohydrocarbon compounds (HCFCs). Drilling has now halted for at least a year. Environmental concerns include both forward and back contamination. Dr. Jatko summarized some of the adverse impacts to the Antarctic environment from drilling operations. Recently, changes to the international treaty have introduced an environmental impact assessment process for Antarctic activities. A Comprehensive Environmental Evaluation, which is similar in scope to an Environmental Impact Statement, is now required. Under the Antarctic Treaty, the Consultative Parties do not have formal authority to approve or disapprove a draft Comprehensive Environmental Evaluation. The 60-day review period does, however, give members an opportunity to bring informal and indirect pressures to bear, if needed. Dr. Rummel asked if the SCAR or others have established a number that would be an acceptable level of contamination. Dr. Jatko said this has not yet occurred. In this area the science community concerned with Antarctic exploration comes together to guide decisions, and there is no simple answer on how clean is clean. In the late 1950's, she said, the concept of environmental protection did not exist. When ice core drilling was undertaken in the 1990s, the way in which the geologists involved viewed contamination was not the same as how biologists view it. There was general and diverse discussion among PPAC members and Dr. Jatko on analogies and potential lessons learned between the issues in exploring the subglacial lakes and space exploration. Dr. Noonan noted that the environmental protocol is a new addition to the Antarctic Treaty and only took effect in 1998. It resulted from obvious contamination issues, such as garbage and contaminated water supplies.

MUSES-C Status/Environmental Actions

Professor Fujiwara gave a presentation on MUSES-C. The samples will return to Earth in 2007. Since the first PPAC meeting in March, the launch has been delayed from November 2002 to May 2003, to address problems in the reaction control system of the ion engine. The targeted asteroid and the payload have not changed. The spacecraft will be launched from Kagoshima Space Center, with a launch window of 3 weeks. The mission scenario and time schedule are unchanged after the time of gravity assist by Earth. The time to return to Earth is also the same as in the plan presented to PPAC in March. Earth swing-by is in May-June 2004. Touch-and-go sampling will be done by shooting projectiles into the asteroid surface and catching ejecta. The spacecraft will leave the asteroid in November 2005. The sample capsule will be returned to Earth by high velocity reentry. After the PPAC meeting in March, the COSPAR Planetary Protection Panel considered MUSES-C, at the request of ISAS and Environment Australia. At the workshop in August, the Panel reviewed the categorization of the MUSES-C mission and concurred with the recommendations of the NASA PPAC. (See Appendix D of the COSPAR workshop report.) Dr. Noonan noted that the PPAC's deliberations and answers to the set of SSB questions on mission categorization had had an impact in answering the issues raised by Environment Australia about the plan for sample capsule reentry and recovery. In mid-May Environment Australia formally approved re-entry of the MUSES-C sample in Australian air space. Professor Fujiwara described three research papers on the target asteroid, which were presented at the Asteroids, Comets, and Meteors Meeting in Berlin this summer. One paper reported that this asteroid is similar to ordinary chondrite meteorites, based on CCD photometry and CCD spectroscopy. A second paper imputed a shape model for the asteroid, based on compiled photometric observations. The third paper found that the near-infrared spectrum of the asteroid is similar to S-III and S-V type asteroids. These papers confirm the asteroid's characteristics as presented to PPAC in March. Dr. Rummel displayed the wording of the approval by Environment Australia, which refers to the review and recommendation by PPAC at its March meeting. Also, on the basis of the PPAC recommendation, NASA has approved the sample return plan and hence NASA's mission participation.

Proposed Draft Mars Sample Return Protocol

Dr. Rummel discussed the status of work on the protocol for handling samples returned from Mars missions. An earlier draft was distributed at the March 2002 PPAC meeting. The final draft of the protocol will incorporate comments from the PPAC members. Dr. Rummel began by reviewing key issues for control of back contamination and the general aspects of the sample handling procedures (quarantine and

types of tests to be performed). Unresolved basic issues include "how clean is clean enough?" and "what level of risk in sample return is acceptable?" A draft number for the risk ceiling in circulation is that the probability of releasing any sample particle larger than 0.2 microns must be no greater than one in a million. Containment methods are being considered now. The plan includes seeking input from the science communities on scientific analysis and assessments that could be done while the contamination screening procedures are being conducted under quarantine conditions. These considerations will be used to draft requirements for the sample receiving and handling facilities. The general types of biohazard testing to be performed include: (1) physical and chemical characterization of the sample to support biohazard testing, (2) biohazard testing, which may involve molecular and organism-based tests, and (3) focused life-detection analyses at the molecular level. A series of five protocol development workshops were held, to develop the draft protocol. An Organizing Committee, which included Dr. Michel Viso, Dr. Rummel, and others, plus a senior-level Oversight and Review Committee, established the workshop process and selected the more than 100 participants. A set of questions on criteria and analytical methodology was posed to the participants (a full list is in Dr. Rummel's briefing slides). The workshops were completed in June 2001, and a full report, which will soon be available, is planned for public distribution for comment later this year. Dr. Rummel reviewed in detail the release criteria for decontainment of Mars samples, as drafted by the workshops. (The release criteria are listed in the briefing slides.) In response to Dr. Zoloth's suggestion for biohazard challenge testing on a non-human primate, Dr. Rummel said a consideration was the phased approach to gradual decontainment (e.g., when to release from BSL-4 to BSL-3) recommended by the workshops and when testing on a primate species would be appropriate. Dr. Noonan suggested that the release criteria wording on biohazard assays for effects/growth on whole organisms might be better expressed with "e.g." [*exemplia gratia*, for example], rather than "i.e." [(*id est*, that is], to allow for inclusion of other species. Dr. Rummel replied that the sense of the workshop expressed in the report is that some of the established rodent models, such as genetically altered "knockout" mouse strains, were more useful than primate models for challenge testing on organisms. The workshops also reported on testing of appropriate materials for contact with samples during quarantine and contamination testing. A notice of availability for comment on the workshop report and draft protocol will be published in the Federal Register in about a month. The members discussed additional ways to ensure the draft protocol is disseminated to relevant audiences and agencies, including international dissemination. The draft protocol and comments on it will be used by project teams preparing for missions with sample return. Dr. Robinson opened a discussion of the importance of stating clearly the context (terms of reference) and definitions used in the draft protocol. The sense of the committee was that a comment period of 120 days after the Federal Register notice would be appropriate and that access via a NASA Internet website would be essential for wide dissemination. Dr. Noonan asked members to provide Dr. Rummel with names and contact information for organizations that should review the document. (A list for this information was circulated on Wednesday morning.) Dr. Noonan also suggested that, although a formal response in the Federal Register to the comments received is not required, it would be well to follow the comment and response process used by regulatory agencies. This would include identification of documents received (response docket), summary of the range of concerns expressed, response to substantive issues raised, and so on.

First Day Wrap-Up

Dr. Carle Pieters expressed concern that SSE omitted PP technologies from its technology assessment. This led to general discussion of efforts needed to support R&D on PP technologies, issues in maintaining the integrity of returned samples, and the extent of planning for sample return and handling in the Mars Exploration and SSE programs. Dr. Noonan suggested that the need for a NASA focus on PP technology development, given the long lead time required and the importance of PP to some science missions, might be the subject of a recommendation to Dr. Weiler. The members raised general concerns about ways in which the PPAC's thinking is communicated to the relevant NASA programs and projects. Dr. Debra Hunt asked when mission proposers are required to address PP concerns. Dr. Rummel replied that the AO includes the PP risk category, and respondents must state how they will address it. For example, the PP category and the requirement to respond to it in an appendix are already included in the AOs for the Discovery program. Dr. Noonan adjourned the day's session.

Wednesday, October 2, 2002

Review of Day 1 and Discussion Items for Day 2

The committee reconvened at 8:37 a.m. The committee reviewed Dr. Noonan's list of suggested issues for future meetings: (1) better understanding of sterilization technologies for spacecraft (detection: molecular versus culture methods; are newer materials compatible with materials in payloads and systems?); (2) more thorough discussion of intellectual property issues; (3) when/how will PP technologies will be addressed as part of the SSE external technology assessment process; (4) presentation on known extremophile organisms (organisms able to survive under extreme conditions), including thermophiles; and (5) facilities planning for PP, with an emphasis on synergy across programs for sample return containment and handling. A sixth item was added for communication strategies for dialogue and dissemination on PP issues. The members circulated a list for names of organizations to be notified about the Draft Mars Sample Handling Protocol.

Update and Status, Mars Exploration Program

Dr. Orlando Figueroa, Mars Exploration Program Director, provided an update on the program. A major reason for exploring Mars, Dr. Figueroa said, is that it is the first planet for which we can realistically assess its habitability (past, present, and future). Mars also provides a "control experiment" for understanding and testing the role of what we think are key state variables in the evolution of life and of Earth-like conditions for life. Third, Mars exploration provides inspiration for scientific exploration in general, increasing student interest in science. The Mars Exploration Program is a science-driven effort to characterize and understand Mars as a system. The strategy is to "follow the water." The exploration approach involves three phases: (1) *seek* interesting sites via orbital observation, (2) perform *in situ* sampling and analysis, and (3) acquire *samples* for return to Earth. Dr. Figueroa next overviewed the program's course by launch year. Mars Odyssey, launched in 2001, is producing breakthrough science, such as findings of significant concentrations—perhaps as high as 50 percent by mass—of subsurface water. Odyssey is providing data for characterization of potential sites for the Mars Exploration Rovers. The Japanese Nozomi Orbiter will arrive at Mars in 2003, although there are indications it may have control system problems when it arrives. The Mars Rovers will be the first mission on the martian surface since Pathfinder. The airbag and parachute technology for landing the Rovers now appears to be working well. The teams are working at a frantic pace to complete the technology development and testing for launch in May and June 2003. At this stage, important systems-level concerns include managing the rover mass to meet mass ceilings for launch, insertion, and landing. The Mars Reconnaissance Orbiter (MRO) will be launched in 2005 to begin a second cycle of seeking, followed by in situ characterization by a smart lander and rover, which will be launched in 2009. The technology development cycle is such that, when new information about Mars is acquired, it cannot be incorporated in technology changes until the next generation of seek–in situ–sample missions. The Mars Scout is a competed mission and is still open as to its mission type (orbiter, lander, rover, etc). Scout proposals are being evaluated. The Italians are contributing a shallow subsurface radar on MRO. The program also includes a joint Italian/NASA orbiter to be launched in 2009. A NASA backup plan for a telecommunications orbiter would use resources programmed for this 2009 collaborative orbiter. A French orbiter mission scheduled for 2007 launch may slip to 2009. Part of the tests with this orbiter will be search/rendezvous for a close encounter with a drifting sample canister (as a pathway to retrieving martian surface samples for Earth return). NASA is working with the Air Force to test key search/rendezvous technologies, in case the French orbiter does not launch in 2007.

Every AO for the program includes a section on PP requirements. A research group at JPL works on environmental and PP issues. There is a dedicated technology budget line for PP technologies. Two areas of interest now are sterilization techniques and materials. Mars sample return missions are not scheduled until after 2010. Issues for the smart lander/rover, scheduled for 2009 launch, include maintaining the state of instruments needed for bioinference analysis. A major problem is maintaining or regaining calibration after launch and landing. Work began on the instrument technology last year. Across the Mars Exploration Program as a whole, technology development is 10 percent of the program budget. The price tag for a sample return mission was estimated at above $3 billion. A team led by Glenn MacPherson re-examined the cost basis and came up with solutions that cost less. Another group is working on exobiology technologies.

In response to a question on forward contamination controls in foreign missions, Dr. Figueroa said that France is a member of COSPAR. To a question about PP control at foreign launch sites, Dr. Figueroa answered that, for surface missions where NASA is involved, the right kinds of people are being engaged in discussions early. The program is investing in three studies of alternatives to achieve a quadrupole mass spectrometry capability for analysis of nitrogen, carbon, hydrogen, and oxygen. Canada has offered to work on technology for sample acquisition and preparation prior to in situ analysis. Dr. Kerridge assessed the program as good for generalized scientific investigation but not focused on looking for evidence of life, which requires optimal sample selection as well as sample return. He thinks a program looking for signs of extinct or extant life must focus on how to get the right samples and return them. A logical progression to this objective is needed, even if the final results are several decades away. For example, what will the 2003 Rover experiments contribute to selecting sites where there may be signs of life? Dr. Figueroa answered that the program is doing as Dr. Kerridge suggests through the cycles of seek-in situ-sample missions. Dr. Figueroa and Dr. James Garvin explained the Rover experiments as contributing to context framing by looking for preserved evidence of persistent water. Dr. Kerridge suggested that the program should not publicly state its goal as looking for life, if the missions for the near future are for a more generalized scientific exploration. Dr. Pieters acknowledged the program's phased approach to scientific and technological issues but wondered if there was a similarly phased approach to sample return. Dr. Figueroa replied that, consistent with the recommendation in the SSB decadal survey, the program is working now on technology that will enable sample return during the next decade. Other PPAC members suggested that the immediate issue for the committee should be forward contamination. In response to a question from Dr. Levy on studies of back contamination control, Dr. Figueroa said that the funding even for preliminary studies had been explicitly cut from the budget. He is not satisfied with the state of knowledge or the cost basis for a sample handling facility. When asked what the PPAC could say on this topic that would be useful, Dr. Figueroa suggested it might be appropriate to recommend that the program at least study the key requirements. The presentation ended with a video presentation on the Mars Exploration Rovers.

Mars Contamination Aspects and Planning

Dr. James Garvin, Lead Scientist for the Mars Exploration Program, began his presentation with an overview of the state of science about Mars. Mars surface exploration started with the Viking landings. The Viking Landers performed experiments with a science payload that cost $290 million in current dollars. The results gave a view of the martian surface as sterile, desiccated deserts with high oxidant loading. Even after Mars Pathfinder, we still do not know how rocks were moved around and laid down in rock fields. Mars Global Surveyor was the reconnaissance stage that allowed questions on Mars habitability to begin to be addressed by targeted observations. Global Surveyor showed annual dust storms that changed surface features drastically. Dynamics of the martian atmosphere were witnessed from orbit. We discovered that Mars' interior had a large magnetosphere in the past, similar in strength to Earth's magnetosphere. This mission also provided enough topographic detail to address questions of where water would flow. It located potential mineralized zones, indicating that Mars had a "fluid cycle" in modern times. If Mars is a planet with a sedimentary record, what was the fluid that produced the wear and sedimentation that Earth geologists see as effects of surface water run-off? The observable scale of the eruption of one large volcano on Mars would have released water vapor equivalent to all the water in the Mediterranean Sea. Even though Mars Global Surveyor was a small, "Scout"-class spacecraft, the observations from it have already resulted in 250 scientific publications. Dr. Garvin expects it to eventually produce "thousands" of scientific papers.

A new step in thinking about Mars comes from the Odyssey mission, which has now been mapping for 7 months. Three instruments on Odyssey are germane to the PPAC task. One is a multispectral near-infrared camera, which can observe mineralogical properties of the surface. Two others provide observations in the middle infrared and visible spectrum. Trails of dust devils can be observed all over the planet. There is evidence of material flows. But perhaps the biggest change in the thinking about Mars comes from the elemental analyses indicating vast deposits of hydrogen-bearing matter in the upper few feet at high latitudes, representing 30 percent of the planet's surface. The concentration of hydrogen is great enough that it implies all the pore spaces of the surface layers are filled. The only explanation so far from the physicists is that this hydrogen is the sign of a vast storehouse of ice-saturated soil and perhaps of underground ice masses. Recent papers argue that, under current martian conditions, some of this water could at times be liquid. The Mars Exploration Rovers will be geologic explorers. So we are going to

Mars in a sea of changing science. For comparison, Mars Global Surveyor had a resolution of 3 m/pixel. MRO will have a resolution of up to 25 cm/pixel. MRO will have nine experiments and six instruments. With respect to preparation for handling samples returned from Mars, Dr. Garvin thinks there are important lessons to be learned from Earth explorations of isolated environments, such as the dry lakes and subglacial lakes in Antarctica, and from the more than 24 meteorites that are likely to have come from Mars.

Dr. Noonan asked Dr. Garvin about the largest challenges for his team with respect to control of forward contamination. Dr. Garvin replied that a priority will be to make definitive analytical measurements on the right martian materials. The Mars Rovers will require the first calibrations at standards comparable to acceptable calibration on Earth. Other issues are getting access to the right materials. He added that the missions in this decade are setting the context, not "looking for life." We do not yet know how to attain a bioburden reduction adequate to prevent contamination, if a surface probe or rover happens into a martian environment that could sustain life.

Before the final presentation, Dr. Noonan discussed scheduling for the next PPAC meeting, in the March–May 2003 time frame. Members were asked to indicate their availability and periods of known commitments, such as major conferences, within the next few weeks.

Planetary Protection Approach, Mars Reconnaissance Orbiter

As an introduction to the presentation by Dr. David Senske, program scientist for the MRO mission, Dr. Rummel noted that the 1992 SSB report, *Biological Contamination of Mars* in effect set the bioburden standard for missions that were not heat sterilized (Viking sterilization). The current detection procedures provide a measure of the surface microbial burden, with "surface" defined as the exposed area of the spacecraft not protected by a high efficiency particulate air (HEPA) filtration system. The original period for biological exploration of Mars was envisioned to be about 50 years, beginning in the 1960s. During that period, forward contamination was to be minimized. Because the period for investigating Mars habitability is now considerably extended, there is an issue of the external and internal bioburden on Mars orbiters, which may crash and deposit materials on the surface or in the subsurface. On penetrators and probes that may go to water-holding areas, there are issues of the maximum bioburden they should carry. Dr. Rummel reviewed the principal recommendations from the 1992 SSB report and noted some of the implicit assumptions in that report about the martian environment that now need reconsideration. With respect to orbiter bioburden, Dr. Senske will discuss the approach to bioburden accounting being used in MRO planning.

Dr. Senske began by saying the PP objective was to avoid sending a lot of "life" with MRO to Mars. MRO will be orbiting at low altitudes to get high spatial and spectral resolution. It will be significantly lower than Mars Global Surveyor or Odyssey. How does an MRO breakup/burnup scenario affect PP? The nominal mission time on orbit is 4 Earth years, plus a 2-year relay mode. In addition to a large instrument assembly for the international science payload, MRO has a large antenna to provide a huge data return capability (>26 terabits) and 20 square meters of solar arrays. The elliptical orbit is 225 to 320 km during the first, observing phase of operation, increasing the risk of atmospheric drag if there are unexpected perturbations of the atmosphere. The PP approach begins with the relation between probability of spacecraft impact and total allowed spore burden for orbiters. The project team plans to take a total spore burden approach, rather than an orbital lifetime standard. The objective is a total spore count not greater than 500,000 at Earth launch. An analysis by Lockheed Martin of how the MRO would come apart, heat up, and partially burn during entry into the martian atmosphere is due on October 15, 2002. The analysis will then undergo review. For this analysis, sterilization is assumed for parts that reach 500 °C for at least one-half second. A preliminary spore count analysis for each element of the spacecraft has been set up, although the spore count estimates in the current version are just starting point guesses to be refined as information is gained. For example, some of the manufacturing processes for electronics may reduce bioburden on those elements by several orders of magnitude below these first estimates.

Dr. Leonard asked if spores on the spacecraft surface could drift into the martian air, even while the MRO was orbiting. Dr. Rummel replied that the ultraviolet radiation environment of Mars may kill any spores that detach. With respect to contaminants other than spores, such as chemical contaminants, Dr. Rummel said that chemical contamination was not in the PPAC charter, just biological contamination. Dr. Rummel

also explained that an orbiting spacecraft typically does not have a set bioburden requirement; the bioburden issue only arises in a "crash" or "lander" scenario. The mission plan is to raise it to a safer (low probability of crash) "quarantine" orbit after the survey period. Dr. Kerridge asked if PPAC should be involved in evaluating the PP plan for MRO. Dr. Rummel replied that the committee needs to know it is being done, and it is within the purview of PPAC to comment, but the planning was in place prior to activation of PPAC. Dr. Rummel suggested that spore survival should be a topic at the next PPAC meeting. Dr. Zoloth asked who is considering issues of chemical contamination if PPAC is not, and Dr. Leonard asked about the procedure for obtaining evidence to substantiate NASA answers to questions asked by PPAC. Dr. Rummel said he would work on providing answers to both questions. **[Action #4. Dr. Rummel will provide information on how chemical contamination issues for Mars missions are being addressed and on procedures for documenting NASA responses to PPAC questions.]** Dr. Zoloth asked that a contextual framework be provided for some of the shorthand, technical answers given to committee questions. Dr. Pieters remarked that the MRO plan appears to be thorough, although she did not have a good sense for the difference in risk for MRO compared with other orbiter missions, given the difference in orbits.

Discussion with Associate Administrator, Office of Space Science

Dr. Edward Weiler joined the meeting during the latter part of the MRO presentation. With respect to some of the comments he overheard, he said the job of PPAC was to raise issues. He encouraged the members to continue raising them. The space science budget is in limbo because NASA, like the rest of the federal government, is now operating under a congressional continuing resolution. This causes particular problems for the new programs in the FY 03 budget: NSI and New Frontiers. Also in limbo is the Kuiper Belt/Plato mission, which is not in the FY 03 Presidential Budget but was an earmark in the FY 02 budget as authorized. Overall, the Presidential Budget is a good budget for OSS, but the markup in the House of Representatives has not yet happened. Dr. Weiler noted that SSE and the Mars Exploration Program together represent more than half of the OSS budget. His biggest concerns are the Mars Rovers because they will receive intense public attention. The NASA Exploration Team (NEXT) has the task of considering architectures to achieve what NASA wants to do in the future, such as human exploration. Fred Gregory, the new Deputy Administrator, is interested in going beyond ISS to deeper space exploration. Code S is working with Code M (Office of Space Flight) on a science-driven human exploration program. The focus will be on technologies that are destination independent, such as NSI and the radiation initiative in Code U. Having more power will be valuable for human exploration of the planets, and nuclear energy will probably be needed. Different lifters than Shuttle will be needed to get mass to orbit without humans on board. The Administrator has said that NASA should be science-driven not destination driven, and Dr. Weiler agrees.

Dr. Noonan described the principal issues raised during this meeting. (1) The committee wants more information on "how clean is clean," and alternative techniques and methods for detection and contamination. How do new materials respond to the currently used methods? (2) Information is needed on biocontamination of extreme environments on Earth, as potential models for forward contamination in space. (3) With respect to the technology assessment done for SSE, PP technologies were omitted in the first round assessment. PPAC members think that at some point an assessment of potential PP technologies is needed, given the long lead time that may be necessary for making investments in this area operational. Some investments are being made in the Mars program, but some study is needed about sample return requirements. Dr. Weiler said that the Mars program has sufficient funding to pursue PP technologies. Dr. Figueroa added that the Mars program is investing in PP technologies and recognizes that the sample handling issues for SSE and Mars are the same. Dr. Noonan agreed but said the PPAC wanted to reinforce the importance of this area. (4) Similarly, PPAC wants to reinforce the importance of having PP included in the AOs for new missions, as is being done already in the Discovery Program. (5) With respect to the Draft Mars Sample Handling Protocol, PPAC advises that it be widely disseminated and advertised. Broad debate is better, given that there is opportunity now for an extended comment period. (6) A related issue of interest to PPAC is how to work toward international public consent for PP approaches. Dr. Robinson asked if there will be opportunity for discussing the cost implications of PP alternatives. What are the internal trades for doing more or less on PP? What resources are needed for alternative approaches? Such information would help to make PPAC's recommendations realistic. Dr. Figueroa said that a real example can be provided, using the cost components for the Mars Exploration Rovers. **[Action #5. Dr. Figueroa**

will provide PPAC with cost comparisons for PP alternatives, using the Mars Exploration Rovers as the example.] Dr. Noonan thanked Dr. Weiler for the support provided by Dr. Rummel, other NASA staff, and the support contractors.

Meeting Wrap-up Discussion

After Dr. Weiler left, the meeting continued with general discussion. Dr. Levy said that the meetings were being largely taken up with listening to broad briefings on context, with little time to hear about or discuss the incisive issues within the committee's purview. The time spent on providing context needs to be balanced with time to deal with the issues for which PPAC was established. Many concerns are mentioned, but it is not clear how they will be carried forward and addressed. Dr. Noonan agreed with his concerns and suggested that the members prioritize the topics they had identified for the next meeting. She asked for input from the members on which issues the committee wants to discuss in a structured way, as opposed to issues for which it would suffice to receive background information without spending meeting time on them. Dr. Rummel said that he saw the committee evolving in a reasonable way through its initial learning phase and beginning to focus on the PP issues. Dr. Levy said it would be useful to have information on how the bioburden ceilings were set, for example, the reasoning used in the 1960s about the probability of growth of organisms. The committee needs to understand the underlying assumptions that set the context. Dr. Colleen Cavanaugh said that the key issues for bioburden are detection and sterilization, which appeared to be the sense of the other members as well. With respect to structuring future meetings, Dr. Kerridge suggested that Dr. Rummel identify any time-critical issues the committee needs to address. In the remaining time, one or two briefings should be scheduled for topics such as sterilization and detection techniques or the state of knowledge about extremophiles. The aim should be to allow as much time for discussion as for presentation, or perhaps a minimum of a half-hour to discuss an hour presentation. Dr. David Klein asked for details on methods of detection being considered, for example in the Mars Sample Handling Protocol. Dr. Noonan adjourned the meeting at 12:40 p.m.

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
Columbia I Room, Holiday Inn Washington Capitol
550 C Street SW, Washington, DC

AGENDA

Day 1—1 October 2002

8:30am	Welcome and Meeting Overview	Norine Noonan/John Rummel
8:45am	Report from the NASA Advisory Council	N. Noonan
9:00am	Annual Ethics Training	Laurie Rafferty, NASA General Counsel's Office
9:30am	Planetary Protection Program Status/Plans	J. Rummel
10:30am	Break	
10:45am	COSPAR Planetary Protection Status/Plans	J. Rummel
11:15pm	Mars Express Planetary Protection	Gerhard Schwehm, ESA
12:15pm	Lunch	
1:30pm	Update, Solar System Exploration Program	Colleen Hartman, NASA HQ
2:30pm	Planning for Antarctic Lake Studies	NSF Representative
3:15pm	Break	
3:30am	MUSES-C status/environmental actions	Akira Fujiwara, ISAS
4:00pm	Proposed Draft Mars Sample Return Protocol	J. Rummel
5:00pm	Adjourn	
6:00pm	Committee Dinner	Annapolis Grill 1160 20th Street, NW Washington, DC 20036

Day 2—2 October 2002

8:30am	Review of Day 1 and Discussion Items for Day 2	
9:00am	Update & Status, Mars Exploration Program	Orlando Figueroa, NASA HQ
9:45am	Mars Contamination Aspects and Planning	Jim Garvin, NASA HQ/J. Rummel
10:30am	Break	
10:45am	PP Approach, Mars Reconnaissance Orbiter	Dave Senske, NASA HQ
11:30am	Discussion with the Associate Administrator	Ed Weiler, NASA HQ
12:30pm	Adjourn	

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)

Individual Members:

Dr. Norine E. Noonan, Chair
College of Charleston

Dr. John Rummel, Executive Secretary
NASA Headquarters

Dr. Ronald M. Atlas
University of Louisville

Dr. Colleen M. Cavanaugh
Harvard University

Dr. Carolyn S. Griner
Spacehab, Inc.

Dr. Debra L. Hunt
Duke University

Dr. John F. Kerridge

Mr. Alan Ladwig
Team Encounter

Dr. Debra G. B. Leonard
University of Pennsylvania

Dr. Eugene H. Levy
Rice University

Dr. Carle M. Pieters
Brown University

Dr. George S. Robinson, III
Robinson & Associates, Inc.

Dr. Diana Wall
Colorado State University

Dr. Laurie Zoloth
San Francisco State University

Representative Members:

Dr. Michael H. Carr
U.S. Geological Survey

Dr. Richard Orr
U.S. Department of Agriculture

Dr. Paul Gilman
U.S. Environmental Protection Agency

Dr. Robert A. Wharton
National Science Foundation

Dr. David Klein
NIAID, National Institutes of Health

International Representatives:

Dr. Michele Regimbald-Krnel
Space Science Program, Canadian Space Agency

Dr. Professor Akira Fujiwara
ISAS

Dr. Gerhard Schwehm
ESA/ESTEC

Dr. Michel Viso
Centre National d'Etudes Spatiales (CNES)

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
Columbia I Room, Holiday Inn Washington Capitol
550 C Street SW, Washington, DC
October 1-2, 2002

MEETING ATTENDEES

Committee Members:

Noonan, Norine (Chair)	College of Charleston
Atlas, Ronald	University of Louisville
Cavanaugh, Colleen	Harvard University
Griner, Carolyn	Consultant
Hunt, Debra	Duke University
Kerridge, John	Univ. of California, San Diego
Ladwig, Alan	Team Encounter
Leonard, Debra	University of Pennsylvania
Levy, Eugene	Rice University
Pieters, Carle	Brown University
Robinson, George	Robinson & Associates
Rummel, John D. (Executive Secretary)	NASA Headquarters
Wall, Diana	Colorado State University
Zoloth, Laurie	San Francisco State University

Representative Members:

Fujiwara, Akira *(Internat'l Representative)*	ISAS
Klein, David (*Agency Representative*)	NIH/NIAID
Orr, Richard (*Agency Representative*)	USDA
Regimbaud-Krnel, Michele (*Internat'l Representative)*	Canadian Space Agency
Schwehm, Gerhard (*Internat'l Representative*)	ESA
Viso, Michel (*Internat'l Representative*)	CNES
Wharton, Robert F. (*Agency Representative*)	NSF

NASA Attendees:

Bergstralh, Jay T.	NASA
DeVincenzi, D.	NASA/Ames
Figueroa, Orlando	NASA Headquarters
Hartman, Colleen	NASA Headquarters
Lucid, Shannon	NASA Headquarters
Norris, Marian	NASA Headquarters
Rafferty, Laurie	NASA Headquarters
Senske, Dave	NASA Headquarters
Weiler, Edward	NASA Headquarters

Other Attendees

Billings, Linda	SETI Institute
Fryke, Ian	ESA
Jatko, Joyce	NSF
Stabekis, Perry	Windermere

PLANETARY PROTECTION ADVISORY COMMITTEE (PPAC)
Columbia I Room, Holiday Inn Washington Capitol
550 C Street SW, Washington, DC
October 1-2, 2002

Presentation Slides Distributed in Hard Copy

1) 2002 Annual Ethics Training for Special Government Employees [Rafferty]
2) Planetary Protection Status and Planning [Rummel]
3) COSPAR Planetary Protection: Status and Planning [Rummel]
4) Solar System Exploration Division: Briefing to the Planetary Protection Advisory Committee [Hartman]
5) Planning for Antarctic Subglacial Lake Studies: Science, Technology, and Environmental Protection [Jatko]
6) Mars Sample Handling for Planetary Protection [Rummel]
7) Mars Exploration Program [Figueroa]

Other Materials Distributed at the Meeting

1) COSPAR/IAU Workshop on Planetary Protection. Williamsburg, Virginia, USA, 2–4 April 2002. Prepared by the COSPAR Planetary Protection Panel.
2) Rich Monastery, "Fighting for a Piece of Mars," The Chronicle of Higher Education 48(42): 2–4. 28 June 2002, and responding letter to the editor by Norine E. Noonan and John Rummel, "Protecting the Earth from Life in Space," The Chronicle of Higher Education 48(47): B14, 2 August 2002.